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ABSTRACT

Data are presented on labor market conditions for science and engineering graduates based on responses of 255 firms to mail and telephone surveys conducted in late fall of 1981. Highlights presented in table, chart, and text indicate: (1) definite and likely shortages were concentrated in the computer and engineering fields; (2) chemical, industrial, mechanical engineering and earth sciences reported a general balance between supply and demand; (3) fields in which job applicants were in excess of needs included physics, mathematics, chemistry, and civil engineering; (4) employer perceptions of shortages of Ph.D.'s were not consistent with those at the lower degree levels; (5) reported shortages were concentrated in industries having experienced overall employment growth in 1981; (6) at each degree level a greater proportion of employers reported shortages for engineering graduates then for science graduates; (7) large firms on the average sought proportionately more new workers than did medium-sized firms; and (8) 43 percent of the employers reporting shortages felt that these were attributable to rapid growth of their industry, while about 2 percent attributed their shortages to competition from other industries. (Author/JN)

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SCIENCE RESOURCES STUDIES HIGHLIGHTS

NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C. 20550 NSF 82-310 JUNE 9, 1982

Labor Markets for New Science and Engineering Graduates in Private Industry

This report presents data on labor market conditions for science and engineering (S/E) graduates based on the responses of 255 firms to a mail and telephone survey conducted in late fall of 1981. It was found that only information on the recruiting experience of new S/E graduates was readily available on a centralized basis. Personnel officials indicated that within each field, however, this recruiting experience was a good overall indicator of market conditions for all scientists and engineers.

The following industries, which account for almost three-fourths of the private industrial employment of scientists and engineers, were surveyed: mining, construction, petroleum refining and extraction, chemicals, primary and fabricated metals, office machines, nonelectric and electric machinery and equipment, aircraft, other transportation equipment, electric and gas services, and engineering/architectural and other business services. The responding organizations employed 102,000 scientists and engineers or about 8 percent of total industrial S/E employment in 1981. Usable responses were obtained from 101 "large" firms and 154 "medium" firms. The large firms employed 90 percent of the total S/E employment reported. For fields that are not widely represented in industry, such as the biological and social sciences, the limited sample precluded meaningful analysis.

Highlights

- Definite and likely shortages[1] were concentrated in the computer and engineering fields. Forty percent or more of employers of bachelor's- and master's-level graduates reported shortages of persons trained in computer science; systems analysis; and electrical, electronic, petroleum, and computer engineering (table 1).
- Those fields in which employers indicated a general balance between supply and demand for bachelor's and master's graduates were chemical, industrial, and mechanical engineering and the earth sciences.
- Fields in which job applicants were in excess of needs included physics, mathematics, chemistry, and civil engineering.
- Employer perceptions of shortages of Ph. D.'s were not consistent with those at the lower degree levels. Thus, a large majority of employers of Ph. D.'s reported adequate or surplus numbers of job applicants in the fields of computer science; systems analysis; electrical; electronic and mechanical engineering; and the earth sciences. On the other hand, over 40 percent of the employers of chemical engineering Ph. D.'s reported shortages in this field. (The number of responses regarding Ph. D.'s in industrial, petroleum, and computer engineering; mathematics; and physics was not sufficient to assess market conditions.)
- Reported shortages were concentrated in those industries that had experienced overall employment growth in 1981. These were office machine (computer) manufacturing, electronic component manufacturing, computer and data processing services, and petroleum extraction.
- At each degree level a greater proportion of employers reported shortages for engineering graduates than for science graduates (chart 1). For example, over 40 percent of employers of bachelor's-degree recipients in engineering fields and 30 percent of the employers of bachelor's-degree recipients in science fields reported more vacancies than qualified applicants. The smallest differential between science and engineering was reported for Ph. D.'s, 30 percent of employers of engineering doctoral graduates versus 25 percent of employers of science doctoral graduates.
- Large firms, on the average, sought proportionately more new workers than medium-sized firms—15 percent of the firm's total S/E employment for large firms versus 6 percent for medium-sized firms. Medium firms were significantly more successful than larger organizations in meeting recruitment requirements.
- A large proportion (43 percent) of the employers reporting shortages felt that these were attributable to rapid growth of their industry. Over one-fourth attributed their shortages to competition from other industries. The most frequent action taken by employers with shortages was to increase recruitment effort. This action was reported by two-fifths of affected respondents. Only 3 percent of respondents experiencing shortages noted that production or R&D levels were affected.

[1] Classes were defined as: (1) an excess in number of vacancies over qualified applicants (shortage); (2) an excess number of qualified applicants over vacancies (surplus); and (3) parity between vacancies and qualified applicants (balance).

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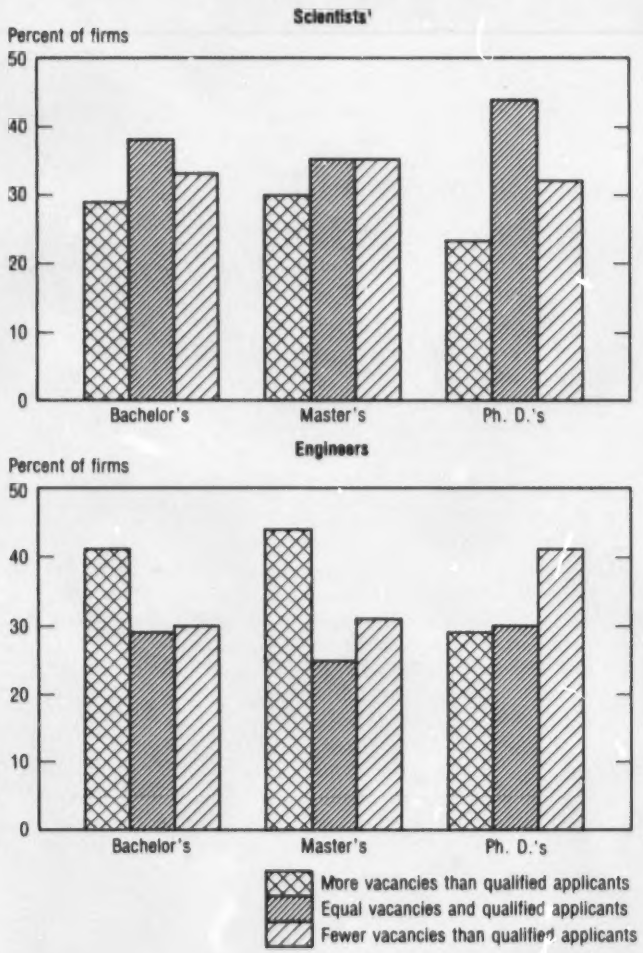
Chart 1. Employers' perceptions of supply/demand balance for scientists and engineers by degree level: 1981



'Excluding biologists, social scientists, and psychologists.
SOURCE: National Science Foundation

Introduction

Labor market imbalances—skill shortages or skill surpluses—are cause for concern because of the resource misallocations they represent and the resulting social and economic difficulties. This analysis concentrates on imbalances between the supply and demand for scientists and engineers in private industry, the largest employment sector for these skills. In particular, it focuses on the hiring and recruitment of new S/E graduates. According to personnel directors of industrial companies, market conditions for this group are a good indicator of market conditions for all scientists and engineers in particular fields.

Several indicators of industrial S/E labor market conditions are examined. The first is "employer perception" of the adequacy of the supply of new graduates. This indicator has the strength of "expert" experience since the respondents were either personnel directors or college recruiting specialists. Perceptions of individual employers were aggregated by giving the response of each employer equal weight. Shortages, however, were more frequently reported by large firms than by medium firms. Therefore, the severity of the problem is probably understated by this indicator. "Employer perceptions" also suffers from the lack of a common definition of what constitutes an "adequate supply." For example, even though all hiring goals had been achieved, some employers reported a shortage because they had had to extend unusual recruiting efforts such as offering higher than desired salaries or hire lower ranked graduates.

Because of the difficulties involved in interpreting and classifying employer opinions, quantitative data were also obtained on hiring goals, actual hires, and on the number of offers made during the recruitment process. These data were used for the development of a second indicator, "hiring success," which is the ratio of actual hires to hiring goals. Both numerators and denominators of the hiring success ratio were summed over all employers. Thus, this indicator is weighted to reflect firm size. A low ratio is clearly consistent with a shortage situation. Ratios near one, however, are indicative of either surpluses or balances. Since labor markets do not adjust instantaneously, job openings can exist even in a situation of balance.

For employer perceptions, market conditions were classified on the basis of reported patterns of perceived surplus, balance, and shortage for each field. Fields in which more than two-fifths of the employers reported more vacancies than qualified applicants, and few employers reported surpluses, were classified as shortages (chart 2). Fields in which the respondents were roughly evenly divided among three classes of market conditions (i.e., shortage, balance, and surplus) were considered to be in balance. Fields in which more than two-fifths of the respondents reported an excess of qualified applicant vacancies, and in which few respondents indicated shortages, were classified as fields experiencing surpluses.

For the "hiring success" indicator, fields in which it exceeded 60 percent were classified as "nonshortage" fields, while those in which the rates were less than or equal to 60 percent were classified as experiencing shortages (chart 3).

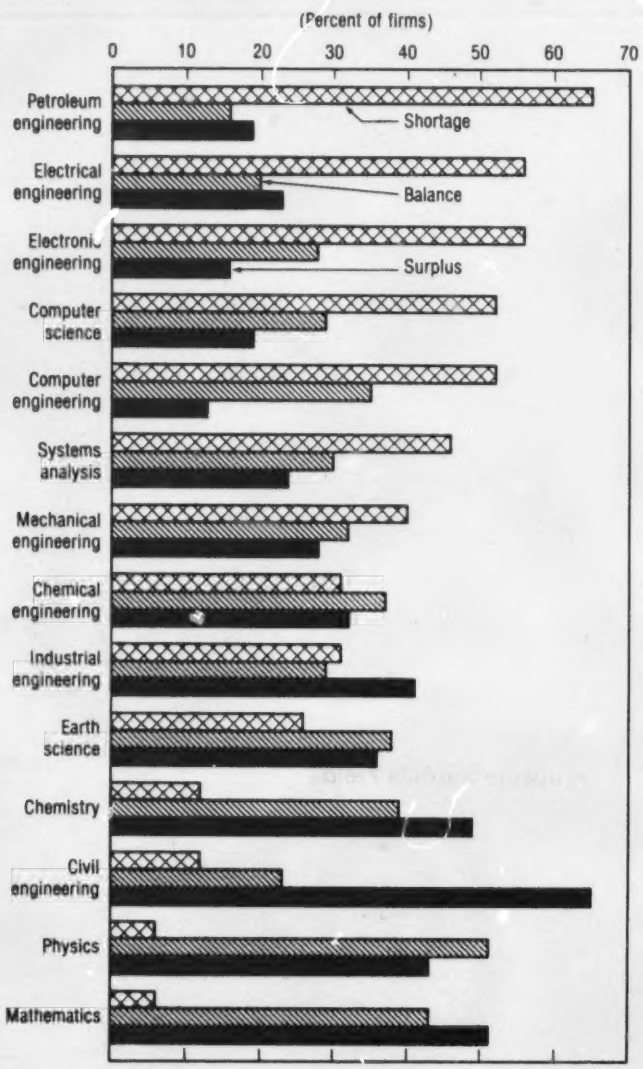
The combination of both "perception" and "hiring success" indicators are used to assign a final market classification to each field (table 1). Employer perceptions' data are used as the primary indicator in classifying industrial S/E labor markets by degree of imbalance. The decision to rely more on this soft statistic is in part necessitated by the absence of historical data on which to base "norms" for more quantitative data.

Table 1.—Summary of market condition indicators

Field	Employer perceptions	Hiring success	Overall
Computer science	Shortage	Shortage	Shortage
Computer engineering	Shortage	Shortage	Shortage
Electrical engineering	Shortage	Shortage	Shortage
Petroleum engineering	Shortage	Nonshortage	Shortage/balance
Electronic engineering	Shortage	Nonshortage	Shortage/balance
Systems analysis	Shortage	Nonshortage	Shortage/balance
Industrial engineering	Balance	Shortage	Balance/shortage
Earth science	Balance	Shortage	Balance/shortage
Chemical engineering	Balance	Nonshortage	Balance
Mechanical engineering	Balance	Nonshortage	Balance
Chemistry	Surplus	Nonshortage	Surplus
Civil engineering	Surplus	Nonshortage	Surplus
Physics	Surplus	Nonshortage	Surplus
Mathematics	Surplus	Nonshortage	Surplus

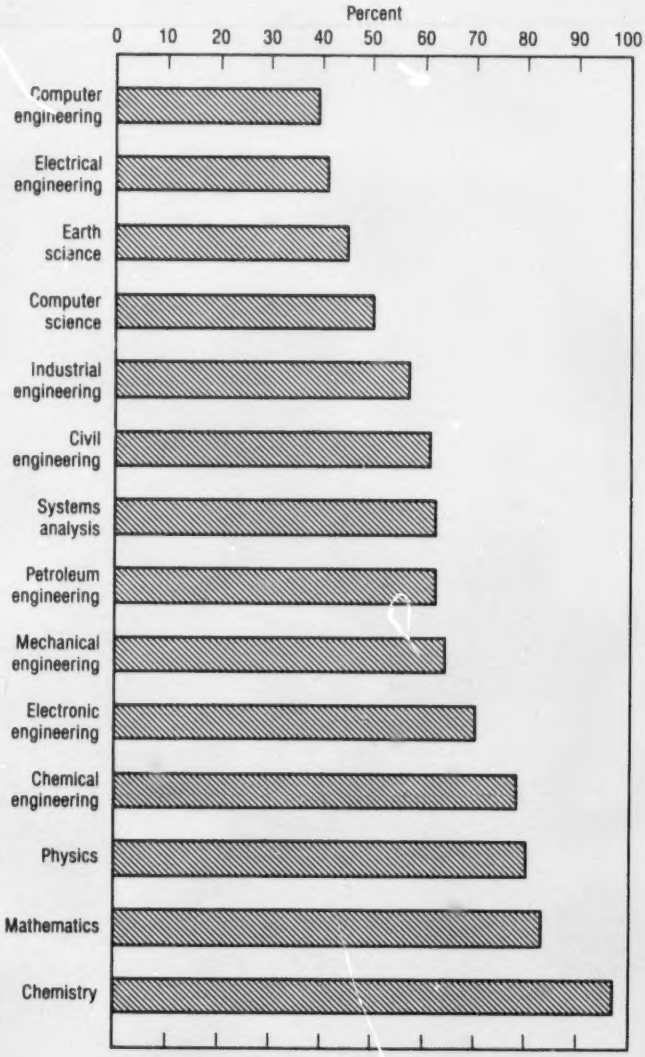
Source: National Science Foundation

Chart 2. Science and engineering fields by proportion of employers reporting shortage, balance, and surplus of new graduates: 1981[1]



[1]Excludes Ph. D.'s
SOURCE: National Science Foundation

Chart 3. Science and engineering fields by degree of hiring success: 1981



SOURCE: National Science Foundation

Data were sought to describe the recruiting experience for the 1-year period November 1980 to October 1981. During this period the economy moved into a recession with total employment growing by less than 1 percent; employment in durable goods manufacturing industries, the primary employers of engineers, did not change at all.[2] This was not true of all industries, however, and comparisons made between survey results and measures of industrial employment growth verify that occupational shortages are closely related to industry growth patterns. The industrial sectors that underwent overall employment growth in 1981—computer-related and some energy-related industries—were the ones that reported shortages of the kinds of scientists and engineers usually employed in these industries.

Probable Shortage Fields

Computer science. Both labor market indicators signify a shortage of bachelor's and master's computer-science entrants. One-half of the respondents indicated more vacancies than applicants (chart 2); hiring success (chart 3) was less than 50 percent—among the lowest of all fields. The number of offers was less than hiring goals, indicating a shortage of qualified candidates. About 75 percent of employers of Ph. D.'s in this field, however, stated that there were adequate or surplus numbers of qualified applicants.

[2]Department of Labor, Bureau of Labor Statistics, Employment and Earnings, Vol. 28, No. 12 (Washington, D.C., December 1981), table B-2.

Computer engineering. Both measures of market conditions indicate a shortage of new graduates in this field. About one-half of the organizations employing these workers reported more vacancies than qualified bachelor's applicants, and 60 percent reported an excess in the number of vacancies for applicants with master's degrees[3]—substantially greater than the average for all engineering fields. Respondents were able to realize only about 40 percent of their hiring goals, the lowest ratio of any field (chart 2). In addition, this is one of the few fields in which hiring goals exceeded offers, signifying a dearth of qualified candidates.

Electrical engineering. Both indicators show shortages. More than one-half of the employers of graduates with bachelor's degrees in electrical engineering indicated that there were more vacancies than qualified applicants. In addition, employers were able to achieve only 41 percent of their hiring goals—the second lowest level for all fields. Perceptions of shortages were even more pronounced for employers of graduates with master's degrees; three-fifths indicated a shortage of qualified applicants. This was not true, however, for new Ph. D.'s. Fully 70 percent of the employers of Ph. D.'s reported either a surplus, or a sufficient number of applicants.

Petroleum engineering. The measures indicated a probable shortage in this field (shortage/balance). About two-thirds of the employers of graduates with bachelor's and master's degrees in petroleum engineering[3] reported fewer qualified applicants than jobs, a larger proportion than in any other field in the survey. Employers reported, however, that about two-thirds of their hiring goals were filled.

Electronic engineering. There is a probable shortage in this field (shortage/balance). More than one-half (54 percent) of the respondents indicated that new graduates in electronic engineering at the bachelor's level were in short supply. For employers of master's- and Ph. D.-degree recipients the figures were 60 percent and 38 percent, respectively. The data indicated, however, a higher than average hiring success, with 70 percent of the annual recruitment goals successfully achieved.

Systems analysis. This is classified as shortage/balance situation. Almost 45 percent of baccalaureate employers and 50 percent of master's employers indicated they had fewer qualified applicants than they sought. Of the employers of Ph. D.'s, fully 75 percent noted an adequate or surplus supply. While the employer perceptions measure indicates a slight shortage of new systems analysis graduates at the bachelor's- and master's-degree level, the hiring success ratio indicates a different circumstance. Roughly two-thirds of the hiring goals of firms were met, suggesting a "nonshortage" situation.

Fields in Which There is a Rough Balance

Industrial engineering. The measures for industrial engineering graduates indicate a probable balance between supply and demand (balance/shortage). Employer evaluations of the state of the bachelor's-level labor market were divided almost evenly among conditions of shortage, balance, and surplus. Almost one-half of the employers of graduates with master's degrees[3] indicated a surplus number of applicants. The hiring success rate for this field, however, was inconsistent with employer perceptions. About 45 percent of employer hiring goals were not met, suggesting a possible shortage situation.

Earth sciences. This field has been classified as probably in balance with the possibility of selective shortages. About three-fourths of the employers hiring in this field reported an adequate or a surplus number of applicants at all degree levels. Only 46 percent of recruitment goals were achieved, however, suggesting a possible shortage of personnel. In as much as these recruiting shortfalls were concentrated in a few large firms, it seems likely that this apparent shortage is not widespread.

Chemical engineering. Both indicators are consistent with a situation of balance in this field. Employer perceptions of market conditions for graduates with bachelor's and master's degrees were almost equally divided among shortages, balances, and surpluses. For Ph. D.'s, however, over 40 percent of employers reported a shortage of applicants. Overall, hiring success at four-fifths of goals was also consistent with a situation of "nonshortage."

Mechanical engineering. The indicators show a balanced situation. Findings for this field, however, varied by degree level. Employers of mechanical engineering graduates with bachelor's degrees were equally divided as to their perceptions of imbalance with about one-third reporting shortages. Nearly one-half of the employers of master's, however, noted a shortage of qualified applicants, while 80 percent of employers of Ph. D.'s felt they had an adequate or excess number of qualified applicants. The hiring success rate of 64 percent of job vacancies was above average for the engineering fields.

Probable Surplus Fields

Chemistry. All indicators suggest a surplus of persons with degrees in chemistry. A surplus of qualified applicants was reported by 50 percent and 45 percent of employers of bachelor's- and master's-degree recipients, respectively. For Ph. D.'s, about 50 percent of the employers noted a balance and 31 percent a surplus of qualified applicants. The demand for new graduates as a proportion of total employment of chemists (5 percent) was among the lowest of the fields surveyed, and reflects in part the decline in total employment in the chemical industry. Employers were able to hire 97 percent of their goals, the highest ratio of any field.

Civil engineering. The depressed conditions of the construction industry have adversely affected the market for civil engineers. A large proportion of respondents, about two-thirds, indicated a surplus of new graduates at the bachelor's, master's, and Ph. D. levels. Employers were able to fill about 60 percent of their goals, a somewhat higher proportion than average for all engineering fields.

Physics. The indicators point to a small surplus of new physics graduates in relation to available industrial jobs. The majority of employers of graduates with bachelor's and master's degrees[3] perceived a balance, but most of the rest noted a surplus of graduates. The hiring success index of 80 percent of goals was substantially above the average for all S/E fields. The interpretation of these data regarding the demand for nondoctoral degree-holders, however, should be treated with caution since these degrees do not generally qualify an applicant for employment as a physicist. It may well be that many of these graduates are being hired for computer-related jobs.

[3]An insufficient number of responses were obtained from employers of Ph. D.'s in the fields of computer, industrial, and petroleum engineering; mathematics; and earth sciences.

Mathematics. The overall picture for new mathematics graduates seems to indicate a small surplus of qualified applicants. Over one-half of the responding employers of bachelor's- and master's-degree recipients[3] indicated an excess number of qualified applicants over available jobs, with the remainder of these employers reporting a balance. Firms were able to fill more than 80 percent of their vacancies, a ratio that is among the highest of the surveyed fields.

Market Conditions by Size of Firms

Demand for new hires (as a proportion of their employment of scientists and engineers) was substantially greater for large firms than for medium-sized firms, 15 percent versus 6 percent. This could reflect a greater desired growth rate on the part of large firms, or a higher labor turnover experienced by these firms. Given their relatively lower goals the medium-sized firms were much more successful in meeting their employment requirements; actual hires exceeded goals by about 5 percent. In comparison, large firms filled only one-half of their relatively larger total recruitment goals. This pattern held for all lds except chemistry and mathematics where large firms were more successful in achieving their hiring goals. The ratios of offers to actual hires, however, were nearly identical for large and medium firms; i.e., slightly more than 2.0. The net effect of these patterns was that actual hires as a proportion of the organizational S/E employment base were about the same for both sets of firms—8 percent for large firms versus 7 percent for medium-sized firms.

Causes of shortages

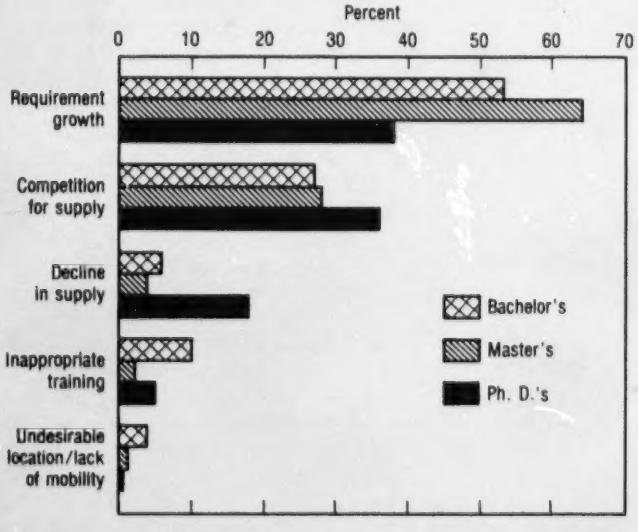
Employers reporting S/E personnel shortages were asked to provide information on their perceptions of the single most important reason for the lack of qualified applicants. For all fields and degree levels, the cause cited most often was "growth in requirements" which accounted for over one-half of bachelor's shortages, two-thirds of the master's, and two-fifths of the Ph. D.'s (chart 4). "Competition from other industries," the next most mentioned cause of shortages, was reported by over one-fourth of these employers.

A mismatch between applicant qualifications and employer needs was not a major factor in perceptions of shortage. Thus, "inappropriate training" accounted for only 10 percent of the responses for bachelor's shortages, 2 percent for master's, and 5 percent for Ph. D.'s. "Decline in supply" was a factor only for Ph. D.'s—about one-fifth of those reporting a shortage noted this as the primary cause. It is interesting to note that employers did not consider geographical location to be a significant factor. Thus, failure to recruit because "jobs are at an undesirable location/ applicants are unwilling to relocate" was not perceived as a major factor in shortages of new graduates; this factor accounted for only 2 percent of the responses. Lack of mobility of experienced workers, however, may be a much more substantial problem in recruiting.

Actions Taken to Alleviate Shortages

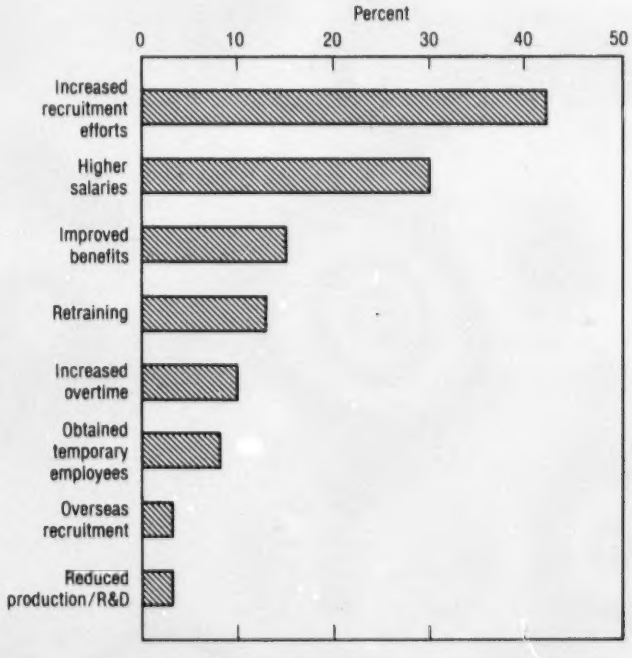
Employers who reported shortages were asked to state what actions, if any, were taken to alleviate the situation. The action reported by two-fifths of all respondents was "increased recruitment effort" (chart 5). Thirty percent and 15 percent of the respondents reported "higher salary offers" and "improved benefits," respectively. In additiion, more than 10 percent of the firms "hired persons with inappropriate training and retrained them." It is notable that only 3 percent of those reporting a shortage of scientists and engineers specified "reduced production or research" as an outcome of these shortages.

Chart 4. Perceived reasons for shortages of new entrants from science/engineering fields: 1981



SOURCE: National Science Foundation

Chart 5. Actions taken by employers to alleviate shortages of new science/engineering graduates: 1981



SOURCE: National Science Foundation